ON *NEOHYALIMAX BRASILIENSIS*, N.GEN., N.SP. (ALLIED TO *HYALIMAX*), FROM BRAZIL.

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PLATE V.

Not long ago I received for examination, from the Berlin Museum, a well-preserved specimen of a small slug, which Dr. Von Jhering had found in Rio Grande do Sul. It had been registered as a *Hyalimax*, and outwardly it resembles that genus. Its general appearance agrees with the figure given by Fischer (1); the mantle, however, is more flattened, and some other differences of minor importance exist, which will be discussed later on.

Since the genus *Hyalimax* is restricted to the Nicobar and Andaman Islands and to Pegu, the discovery of a closely allied form in Brazil is of great note, the importance of which is yet further increased by the fact that there is a striking deficiency of slugs in the neotropic region. Heynemann (2) enumerates from Mexico, Central America, Columbia, and the West Indies (omitting *Limax* and *Vaginula*) the genera *Tebennophorus*, *Megapelta*, *Peltella*, and *Cryptostracon*, and no other genus from the whole of South America. From the adjacent parts of North America we have *Arion*, *Ariolimax*, *Prophysaon*, *Hemphillia*, and *Pallifera*. The indigenous genera apparently have but a limited distribution. Without dissection it is impossible for me to throw any light upon the mutual relations of these genera, but there is no difficulty in eliminating them from the present discussion, because those genera living in Brazil which somewhat resemble the new slug—*i.e.* *Cryptostracon* and *Peltella*—have ribbed jaws.

The specimen in question, being unique, cannot be sacrificed, so the following description of it is necessarily imperfect.

The animal is a true slug, *i.e.* there is no opening in the mantle; nevertheless, it is not limacoid, for the body is flattened, the foot-sole is too broad, and the mantle too much expanded. Length, 17 mm.; breadth of the foot, 7 mm. The foot-sole is of a pale flesh colour, without grooves. The locomotor disc can only be distinguished from the sides towards the posterior end. The mantle occupies the full breadth of the animal, and half its length. It is flat on the upper surface, thus corresponding with the shell below. There is no mantle-cap, as in *Limax* or *Arion*, the prominent declivous portion not being broader than the mantle edge of *Helix*. The skin of the neck is united to the mantle almost immediately behind its anterior margin, and in front of the shell. The mantle has a groove all round the margin, a little deeper in front than behind. The pulmonary aperture is on the right-hand side of the mantle, somewhat behind the middle (Pl. V, Fig. 2). Although the mantle margin is thick and fleshy, the shell

and some obscure markings beneath it are visible through the thin, transparent dorsal region. A yellow spot (Pl. V, Fig. 1, *y.s.*) on the left side near the posterior end of the mantle looks as if it were the nucleus of the shell; this, however, is an illusion. The rest of the integument is smooth, with scarcely a wrinkle; indeed, it is difficult to trace the boundary of the foot-fringe (which I have named the "Sohlenleiste") by means of the parapodial groove (pedal-groove of Pilsbry). Only two tentacles are present, viz. the ommatophores. The genital opening is situated immediately behind the right tentacle, and appears as a fissure slanting obliquely towards the foot. In front of the foot-sole there is a broad transverse groove, as in all Stylommatophora. The mouth is situated directly above and almost within this groove, and is bounded on either side by a labial lobe. These lobes do not meet, a small free space being left immediately above the mouth itself. It thus offers a contrast to *Hyalimax Maillardi*, the upper lip of which presents a more complete arc. No osphradium ("Geruchsleiste") was observed beneath the mantle margin. The upper surface is of a very pale ochre colour, with a shade of lilac, principally on the surface of the mantle; greyish or blackish spots are scattered over it. The tail has two black bands shading off laterally. Rows of fine spots mark the median neck groove and the margin of the foot. The whole skin, though preserved in a firm condition, is transparent; hence it may be inferred, from analogy, that during life all the organs can be distinguished through the integument.

The mantle-sac and the shell.—The mantle encloses a large cavity, which is completely filled by the shell. This latter is a small flat plate of 9 mm. in length, and 6 mm. in breadth (Pl. V, Fig. 3). It did not appear to be attached at any point to the base of the cavity. Beneath the light-yellowish periostracum the lime was deposited in concentric rings, with an excentric nucleus to the left of the posterior end. The nearer the nucleus, the thicker is the shelly matter. The periphery is solid, surrounded, near the posterior right-hand margin, by a brown conchiolin line. The nucleus is somewhat thickened; the shell throughout is perfectly flat, and therefore does not enclose any of the soft parts. In *Hyalimax* it is slightly arched (Fischer). One is surprised to find that the yellow spot in the mantle is not over the nucleus of the shell. This spot forms the undermost layer of the mantle itself (Pl. V, Fig. 5). It is structureless and of a hard cartilaginous nature. The black spot above it is situated on the surface. It consists, not of a single chromatophore, but of a group. I consider, however, that the yellow spot is the primitive shell. This is demonstrated by its structure and position; for if the shell in the course of its growth increased slightly at its posterior end, the primitive shell, between which and the integument there is a singularly close connection, could not fail to become separated from it.

The pallial organs.—The membrane which constitutes the floor of the mantle cavity also forms the roof of the pulmonary chamber (Pl. V, Fig. 4), of the pericardium, of the nephridium, of parts of the liver, and of the intestine. The floor of the pulmonary chamber is smooth, colourless, and transparent. The details shown in Fig. 4

relate to the roof only. This presents a honeycombed structure, marked over with black, which disappears towards the left side. The pigmentation is most intense at the periphery. Thence some blackish threads radiate towards the pericardium: this blackish network attains its greatest density in the right corner of the pulmonary cavity, where respiration is most active. These blackish rays are visible from the outside through the shell and the mantle wall. The position of the heart is remarkable, it being situate on the short base of the elongate, triangular, yellow kidney, or nephridium. The latter bears the secretory lamellæ on its upper side, and these lamellæ are bound together by transverse, oblique connectives.

The pigment.—In addition to its occurrence in the roof of the pulmonary chamber, melanine is deposited in certain places in the interior of the animal, viz.—(1) As in all Stylommatophora, in the great, brown retractor muscles of the ommatophores; (2) in the wall of the hermaphrodite duct (Pl. V, Fig. 9, *h.d.*); (3) on the surface of the hermaphrodite gland, or gonad. This gland is situated on the left side, behind the liver, and is partly covered by a thin projecting portion thereof; it bears, on its outer side only, an ink-like spot of pigment, which also extends partly over the projecting process of the liver. I think the only conclusion to be drawn from this distribution of the pigment is, that its deposition results on the one hand from activity of growth, or function, and on the other from the action of light. Probably its deposition in the body-wall corresponds with the distribution of the nerves.

The alimentary system.—The pharynx and the alimentary canal, with the salivary glands and the two digestive glands, have the general form shown on Pl. V, Fig. 6. The jaw (Fig. 7) is brown, and has a sharp edge, with a slight median process (*oxygnath*) and a lighter-coloured palatal plate (*elasmognath*), the two posterior corners of which are somewhat prominent. This plate is finely sculptured, the thread-like markings converging towards the median projection. In the radula (Pl. V, Fig. 8) the median tooth is tricuspid, the middle cusp being very large. In the lateral teeth the median cusp is still larger, and directed obliquely towards the middle line of the radula; the inner cusp is reduced in size, whilst the outer one is duplicated. In the marginal teeth the inner cusp increases in size, whilst the exterior outer cusp subdivides, giving rise to three outer cusps (Pl. V, Fig. 8, No. 20). It is, however, uncertain whether the outermost tooth in the figure be a true marginal. The contents of the stomach were somewhat darker than is usual in carnivorous slugs. Plant fibres were observable. I came to the conclusion that the animal had not fed on green leaves, but on dead ones, that had fallen to the ground, on which it lives.

Genitalia.—The specimen is fully developed. The tubules of the roundish gonad converge towards the black hermaphrodite duct, which terminates in a small, slender, pale vesicula seminalis (Pl. V, Fig. 9). The albumen gland is yellow, small and kidney-shaped. Immediately beyond this the male and female ducts separate, no true hermaphrodite duct being formed. The male duct, or prostate, is wide and glandular,

becoming suddenly narrower to form the vas deferens, which also bears in its proximal portion some glandular swellings. The short retractor penis originates in the diaphragm, and has its distal insertion at the junction of the vas deferens with the long penis. The latter consists of a narrow spiral portion and a wider distal one: a true epiphallus cannot, however, be distinguished. Probably the sperm is not enclosed in a spermatophore, but freely ejected. The upper part of the pale-yellowish oviduct is wide and glandular; the distal portion is narrow and cylindrical: after uniting with the duct of the elliptical receptaculum seminis it forms a long vagina. A common atrium genitale is barely distinguishable. The receptaculum contained only mucous matter, and no traces of spermatophores: this accords with the structure of the penis. The inner walls of the penis and vagina are lined with papillæ. Those of the latter are cartilaginous, and disposed in rows of six, and higher up of five, presenting the appearance of a head of maize (Pl. V, Fig. 10). Those of the penis are stout and conical in shape, and vary somewhat in size (Pl. V, Fig. 11). The suggestion may be hazarded that during copulation the papillæ of the penis (*Reizpapillen*) interlock with those of the vagina.

The nervous system.—The most significant point about the nerve-collar is the shortening of the visceral commissure. The cerebral ganglia are connected by a long commissure, equalling in length the maximum diameter of a single cerebral ganglion. The arrangement of the buccal ganglia is precisely similar. The lateral connectives are, however, shorter than the cerebral commissure. The pedal ganglia are united as in all Stylommatophora; the pleuro-visceral ganglia, welded into a single transverse mass, lie immediately above them. This mass is narrower in the middle than it is towards the sides. The union of the ganglia appears to be very intimate, since there is apparently only a feeble connective-tissue sheath. The origin of the nerves I have not been able to trace out.

The muscular system and tentacles.—The degree of development of the tentacles seems highly interesting, since I can distinguish only two, *i.e.* the ommatophores, the lesser pair being wanting. Possibly a small knob on the left side might be interpreted as representing one; but since I found no corresponding one on the right side, this knob was probably a projection of the pedal gland, or a lobe of Semper's organ, or a mesenterial thickening. Indeed, the various delicate structures around the mouth are difficult to distinguish. I think it is certain that the smaller tentacles, if not wanting altogether, are yet more reduced than in *Succinea*. The right ommatophore embraces the penis on the outer side, as in *Helix*. The columellar muscle resembles in a certain sense that of *Urocyclus* or *Parmacella*, but a more careful investigation reveals some distinctive differences. The short, common stem originates on the right side of the posterior margin of the mantle-line. There is some reason for the suggestion that this point originally coincided with the nucleus of the shell and the yellow spot on the mantle above described, a divergence taking place during growth. Further on, the muscle splits up into

four bundles, the two shorter and inner ones being inserted in the buccal mass or pharynx, whilst the lateral ones are attached directly to the body-wall on each side of the mouth. These are not pigmented. The right lateral bundle lies on the inner side of the penis. The muscles of the ommatophores, which have slender terminations, unite with these bundles at a point near the cerebral ganglia, and represent only secondary branches of them. Thus the distal ends of the lateral bundles are on the same level as the roots of the ommatophores, the bundles themselves occupying the places of the missing smaller tentacles.

The pedal gland.—The pedal gland opens below the mouth, and is one-fourth the length of the body. It is sharply circumscribed, and somewhat flocky, the excretory duct being visible from the upper side. It is attached to the body-wall by mesenterial tissue.

Generic position.—It is much to be regretted that Fischer, when describing his *Hyalimax Maillardi*, paid no attention to the separation of the male and female ducts, the tentacles, the columellar muscle, the pedal gland, etc.; nor have we any information whether the shell envelops any portion of the intestinal sac or not, so that a correct comparison is very difficult. As far as it is possible to arrive at any conclusion, the Brazilian form agrees perfectly with *Hyalimax* in its habitat, its mantle, its foot-sole, jaw, radula, and the simple termination of its genital organs, as well as in the lack of accessory glands, dart sac, etc. The sole difference consists in the position of the genital opening. This in the Brazilian form is nearer to the ommatophore than in the true *Hyalimax*. The difference in the insertion of the receptacular duct is only one of specific, not of generic, value. It, however, seems very probable, considering the wide geographical separation of the two, that more exact investigation would bring further differences to light. I therefore propose to call the new form *Neohyalimax Brasiliensis*, which may rank either as a subgenus of *Hyalimax* or as a new genus altogether; the value of the more flattened shell and more forward position of the genital opening being merely subjective.

Position in the family: (a) *Its relation to the Succineidæ.*—The foregoing description demonstrates that *Neohyalimax* is closely allied to *Succinea*, on the basis of the following points of resemblance: the clasmognathous jaw; the radula; the early separation of the genital ducts; the absence of accessory genital glands; the wide separation of the supra-pharyngeal ganglia; the fusing together of the pleuro-visceral ganglia; the position of the heart; and the absence of foot-sole grooves. Possibly to this may be added the distribution of the blood-vessels in the wall of the pulmonary chamber, the respiratory area being equally divided into an intestinal lung and a columellar lung ("Darmlunge" and "Spindellunge") in Semper's sense (3). This hypothesis is founded on the suggestion that the principal black line in Fig. 4 is identical with the principal pulmonary vein. The relationship of *Neohyalimax* to the neotropical genus *Homalonyx*, which is placed between *Hyalimax* and *Succinea* in the textbooks (Fischer, Pilsbry), is more critical. Decision on this point must be deferred until a further and better

investigation of the present genus has been made. At present the connection with *Hyalimax* seems to be the more intimate; but possibly we have only to deal with the results of convergence. The Succineidæ, which show great predilection for moisture, in spreading out from a northern centre across the Equator would seem to have given rise to several forms of slugs. *Hyalimax* on the one side, *Homalonyx* and *Neohyalimax* on the other, would be southern outposts. This hypothesis would be in accordance with the theory put forward by Dr. Haacke and myself, that the greatest number of groups of terrestrial animals originate in those parts of the world where the continuity of land is greatest. An entirely different conclusion would result from the evidence of a nearer relationship between *Hyalimax* and *Neohyalimax* than between the latter and *Homalonyx*. It would accord with the idea of an old Jurassic land connection between South America and Africa. *Hyalimax*, indeed, is not African, but restricted to the Indian region; there is, however, a form from Kilimandjaro described by Von Martens as *Parmarion Kerstenii* (4), which is likely to be nearly allied thereto. I merely wish to show by these remarks that a more intimate knowledge of these animals would throw light upon questions of very general interest.

(b) *Its relation to the Athoracophoridæ.*—Succineoid slugs, such as *Hyalimax* and *Neohyalimax*, are in a certain sense of general systematic importance. Placing the Succineidæ at the end of the quadritentaculate Stylommatophora, the textbooks include the rest as Bitentaculata, in the families Athoracophoridæ, Vaginulidæ, Oncidiidæ, overlooking the disappearance of the smaller tentacles in some small Pupidæ, etc. I group these three families under Mesommatophora, taking the Athoracophoridæ as a transitional form. Fischer joins the Athoracophoridæ to the Succineidæ, and groups together the Vaginulidæ and Oncidiidæ as Ditremata. Pelseneer places the Succineidæ, with *Athoracophorus*, at one end of the Stylommatophora, and the Vaginulidæ and Oncidiidæ at the other. I should not like to do so. The intimate fusion of the pleuro-visceral ganglia demonstrates the derived character of the Succineidæ; on the other hand, the total absence of a columellar muscle is an important point of agreement between the Athoracophoridæ and the Ditremata, the lack of a common atrium genitale in the Succineidæ forming a transition to the state of separate genital openings which obtains in the Ditremata. *Atopos* would be the intermediate form. The relationship between the Succineidæ and the Athoracophoridæ has been founded upon the similarity of their jaws and radulæ. Perhaps the columellar muscle of *Neohyalimax*, in which the retractors of the tentacles attain a certain degree of independence, may prove another point of affinity. Nevertheless, the pallial organs, even though imperfectly known, exhibit a wide divergence. For this reason I should prefer the arrangement given by Fischer, *i.e.* Succineidæ, Athoracophoridæ, Vaginulidæ, Oncidiidæ, with the modification that each of the three latter families is to be looked upon as independent.